Co-designing opportunities towards the development of Irish offshore wind

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Deliverable D4.14 Final report on the assessment of seabird vulnerability to offshore windfarms in Ireland

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V2	24/10/2019	Revised with the comment on the labels associated with risk in the maps, following standard methodology	Emma Critchley	Mark Jessopp	Mark Jessopp

Executive Summary:

It is essential that the potential risks to seabird populations from offshore windfarms in Irish windfarms are assessed prior to development in order to avoid and mitigate impacts. Seabird vulnerability indices have been developed as part of the biological component of EirWind Work Package 4 through updating previously published indices in an Irish context, incorporating new data, and accounting for advances in turbine technology. Two Collision Vulnerability Indices were calculated, one accounting for a turbine sweep zone starting at 20 m above sea level, and one accounting for a turbine sweep zone starting at 40 m above sea level. A separate Displacement Vulnerability Index (DVI) was calculated in order to assess the population level vulnerability to displacement from important habitats due to the siting of offshore wind developments. Vulnerability scores were applied to the most recent seabird distribution data to produce seabird vulnerability maps covering the entire Irish Exclusive Economic Zone (EEZ). Seasonal seabird distribution data were sourced from the ObSERVE aerial survey programme (Rogan et al. 2018) and modelled foraging radius distributions (Critchley et al. 2018). Vulnerability maps were produced for summer and winter showing the areas of highest seabird vulnerability to windfarms, whether due to collision or displacement/avoidance of infrastructure in Irish waters on a broad scale.

The outputs of this report determine spatial vulnerability at a national scale to help broad-scale siting decisions, and finer-scale vulnerability maps should be generated within smaller areas of interest to help inform siting decisions and additional survey/data needs to mitigate potential impacts. The relative importance of coastal areas in the summer compared to offshore areas, especially on the south west coast, can be seen across indices. This reflects the concentration of birds in waters surrounding colonies during the breeding season, including internationally important populations. Additional seabird surveys at a national level will help to reduce uncertainty in areas with limited data (e.g. the

south and west coasts), and at a site level will provide fine-scale information about areas of highest vulnerability. Vulnerability Indices also illustrate how species and risk factors will vary by site and season. Combined use of vulnerability indices and site specific species distribution maps will provide a powerful tool for defining the species and areas most at risk in a planned development site. Appropriate monitoring and mitigation measures can then be put in place prior to development, with the aim of reducing the environmental impacts from offshore windfarm development.

	List of abbreviations
AA	Appropriate Assessment
EIA	Environmental Impact Assessment
CVI	Collision Vulnerability Index
DVI	Displacement Vulnerability Index
EEZ	Exclusive Economic Zone
OWF	Offshore wind farm

Contents

1 Introduction

This report contains results from the assessment of seabird vulnerability to offshore windfarms in Irish waters as part of the biological component of EirWind Work Package 4.

Seabirds spend a significant portion of their time at sea where they may be vulnerable to impacts from marine energy infrastructure including offshore windfarms. Uncertainty around impacts on seabird populations from offshore wind turbines has been one of the greatest impediments to consenting of offshore wind developments. Therefore, it is essential that the potential risks to seabird populations, either through collision with turbines or displacement from important foraging areas, are assessed prior to development. Efforts to assess potential impacts to seabird populations in light of increasing development of marine renewable energy infrastructure have recently focussed on using vulnerability indices. Whilst windfarm vulnerability indices have previously been developed by BirdWatch Ireland, the index uses an older methodology that does not account for potential attraction or avoidance of seabirds to energy infrastructure, and was based on somewhat outdated and patchy seabird distribution data. EirWind deliverable report 4.11 details the rational for a new assessment in Irish waters, and provides an overview of the choice of methodology. EirWind deliverable report 4.12 then provides a detailed methodology to a) develop an index for seabird vulnerability to offshore wind in Irish waters, and b) generate collision and displacement vulnerability maps for seabirds in the western Irish Sea. This methodology has now been used to produce vulnerability maps for seabirds in the entire Irish Exclusive Economic Zone (EEZ). These vulnerability maps use the most recent and comprehensive distribution data from extensive aerial surveys undertaken as part of the Irish government funded ObSERVE programme (Jessopp et al., 2018; Rogan et al., 2018) coupled with predictive distribution models (Critchley et al. 2018) for un-surveyed areas.

2 Methods

2.1 Vulnerability indices

An updated Collision Vulnerability Index (CVI) for seabirds in Irish waters was generated following the methodology set out in Certain et al. (2015) and incorporating attraction/avoidance of infrastructure by Wade et al. (2016). Full details of the methodology are available in Eirwind D4.12 'Initial results for the assessment of seabird vulnerability to offshore windfarms in Ireland', and summarised below:

1) Collating species-specific data on factors that could influence individual vulnerability and population level sensitivity to collisions with offshore wind turbines;
2) Updating factors with the most recent data;
3) Scoring all factors on a five-point scale, with a score of 1 indicating low vulnerability and a score of 5 indicating high vulnerability, and then normalising scores to range from 0.2 to 1;
4) Grouping factors into one of three components: a) Habitat overlap, b) Risk of collision, and c) Conservation status;
5) Developing a formula to combine the factors based on recommendations by Certain et al. (2015);
6) Generating vulnerability scores and rankings for each species.

These steps were repeated to generate a separate Displacement Vulnerability Index (DVI), in order to assess the population level vulnerability to displacement from important habitats due to the siting of offshore wind developments.

The formula for the Collision Vulnerability Index (CVI) is as follows:

$$CVI = ((1 - A1) \times B1 \times B2)^{(1-(\frac{B3+B4}{2})/((\frac{B3+B4}{2})+0.5)} \times ((C1 + C2 + C3)/3)^{(1-C4/(C4+0.5))}$$

The formula for the Displacement Vulnerability Index (DVI) is as follows:

$$DVI = (((A1 + A2)/2)^{(1-A3/(A3+0.5))}) \times ((C1 + C2 + C3)/3)^{(1-C4/(C4+0.5))}$$

2.2 Distributions

To assess the vulnerability of seabirds spatially, the vulnerability indices (CVI & DVI) were applied to seasonal distributions of all seabirds in the Irish EEZ.

Seasonal seabird distribution data were sourced from the ObSERVE aerial survey programme (Rogan et al. 2018). Aerial surveys were conducted over the summer (May-July) and winter (November-February) in two years (2015-2016) from a Britten-Norman BN-2 Islander fixed-wing aircraft with two observers located on either side of the plane. Survey transects were designed to provide equal coverage probability for the survey area, which were positioned differently for each survey year to maximise area covered. Survey coverage focussed on offshore waters, although a coastal stratum was surveyed in the Irish Sea (Fig 2.1). All seabirds were recorded within a 200m transect on either side of the plane, and a time and location-stamped record of species (or species group where species-level identification was not possible), behaviour (e.g. flying, sitting, flushed, diving) and group size was made when animals were abeam of the aircraft.

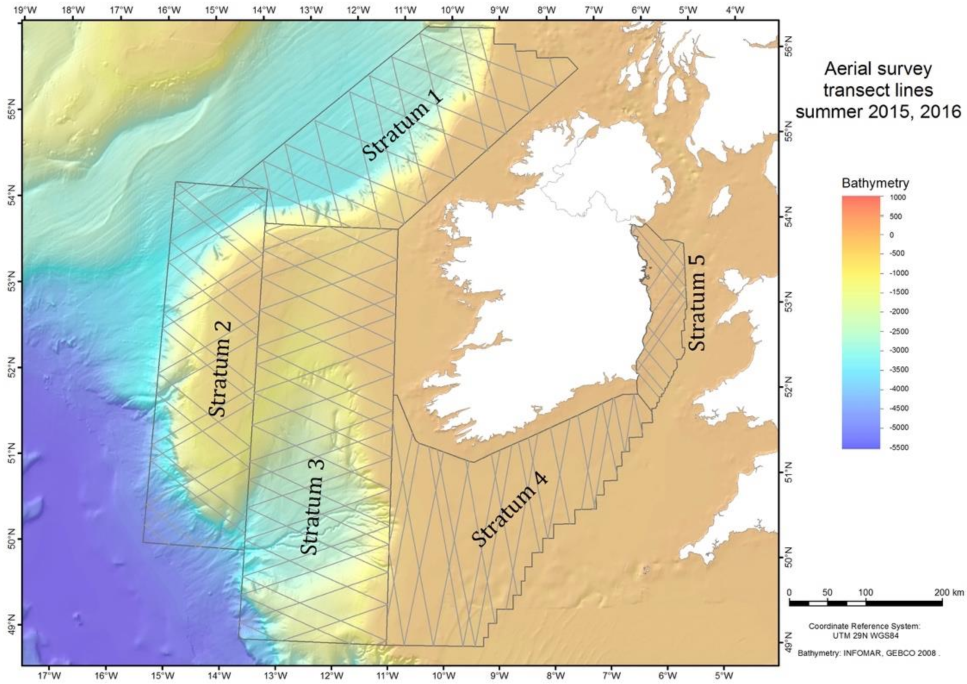

Fig. 2.1. Map of survey area identifying broad strata and transect lines flown in 2015 and 2016.

Each species (or species group, see Table 2.2) abundance was modelled across 0.10 x 0.06 degrees (latitude x longitude) grid cells following Cañadas & Hammond (2008).

Table 2.1. Offshore distribution data from ObSERVE aerial surveys (2015 – 2016)

Species / Group	Seasonal coverage
Northern gannet	summer and winter
Northern fulmar	summer and winter
Herring and common gull	all seasons combined
Black-backed gulls	all seasons combined
Black-legged kittiwake	summer and winter
All gull species	summer and winter
Manx shearwater	summer
Petrel species	summer and winter
Auk species	summer and winter
Tern species	all seasons combined
All seabirds	summer and winter

Unfortunately, aerial surveys did not cover large inshore areas, known to be important for a range of seabird species. Rather than model outdated (1970-2010) and patchy seabird data from opportunistic at-sea surveys held in the European Seabirds At Sea (ESAS) database, data gaps for the coastal areas were filled in using spatial modelling. A number of different methods were tested to find the most suitable approach. Initially, data gaps were filled in using inverse distance weighting (IDW) interpolation, which assigns values to missing data points based on a weighted average of the values of neighbouring points. Figure 2.2a shows example of this method for the distribution of auks (puffins, razorbills and guillemots). This method predicted very small (approaching zero) values at the coast, which are unrealistic given the large numbers of breeding seabirds along the coast in summer. We therefore applied a foraging radius approach from known seabird colonies. This predicts seabird distributions based on species-specific foraging ranges and colony sizes, and has been shown to provide good agreement with tracking and aerial survey data (Critchley et al. 2019). When combined with ObSERVE distributions, this provides the most comprehensive coverage for seabird distributions in Irish waters, see Figure 2.2b.

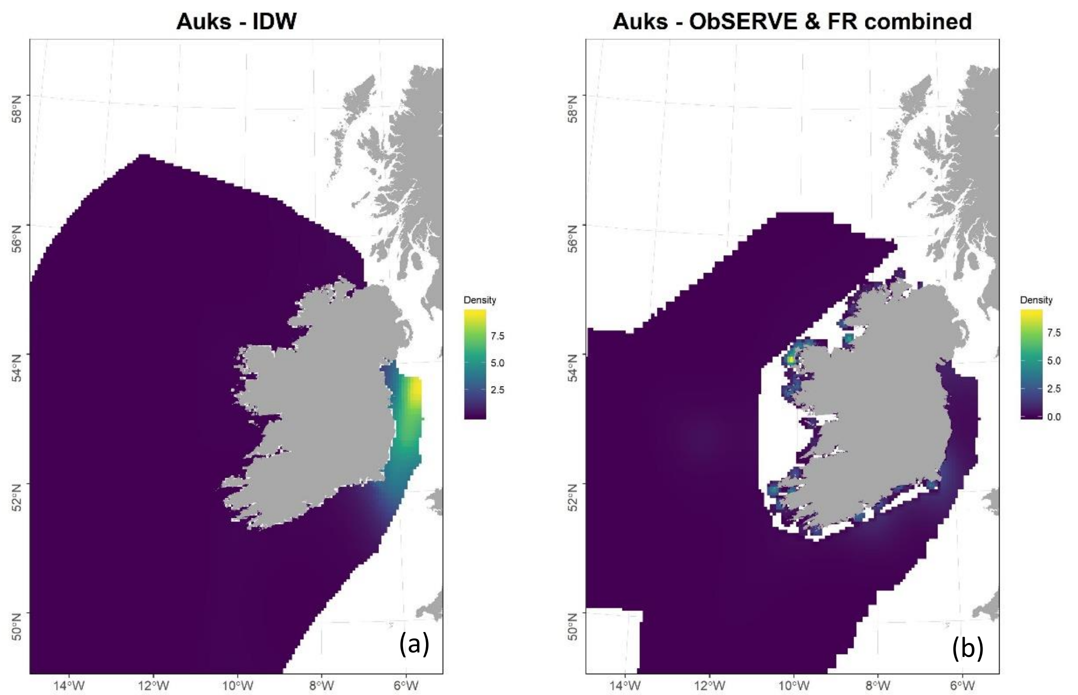

Figure 2.2 Predicted distribution of auks in Irish EEZ using a) inverse distance weighting (idw) interpolation of ObSERVE aerial survey data; and b) combined ObSERVE aerial survey and foraging radius distributions.

Foraging radius distributions were generated for each species following methods set out in Critchley et al. (2018), using the mean maximum foraging range. Each individual colony distribution was clipped to 10 km prior to combining into a regional distribution as the foraging radius method works best for shorter foraging ranges (see Critchley et al. 2019). ObSERVE distributions were converted to the same density (birds per 5 km^2), resolution (5 km^2), and geographic projection (WGS84 UTM 29) as the foraging radius distributions prior to the projected coastal distributions being added to the missing coastal areas from the ObSERVE aerial data. Kriging was used to fill any remaining gaps between the ObSERVE and foraging radius distributions. This method estimates the values for missing data using weighted averages formed by the nearest data points whilst also accounting for spatial autocorrelation. This methodology was followed for each of the species/groups in Table 2.1. Broad-scale offshore ObSERVE distribution data was not available for cormorant/shags, as they are coastal foragers and do not occur in offshore areas. To produce Irish EEZ distribution maps for cormorant/shags, foraging radius distributions were instead combined with ObSERVE distributions from the Irish Sea prior to interpolation.

2.3 Vulnerability maps

Collision vulnerability maps were produced for each species/group by dividing seabird density in each grid square by 1-vulnerability score, (see Eirwind D4.12). To give greater distinction between high and low risk species, vulnerability scores were first normalised to between 0.99 and 0, inflating the scores for high risk species and reducing the scores for low risk species. Species-specific collision vulnerability index maps were then summed together to assess overall risk to seabirds in the region, accounting for both a 20 m and 40 m sweep height of small and large wind turbines. The method was repeated using the Displacement Vulnerability Index (DVI) scores to produce separate maps of displacement vulnerability.

3 Results

3.1 Vulnerability scores and rankings

Seabird collision and displacement vulnerability scores and rankings can be found in Table 3.1 below. The range in collision vulnerability scores was found to be lower for the 40 m index (0 – 0.308) than the 20 m index (0 – 0.407), however the change in score varies by species with a subsequent change in rankings across the two indices. For example, large gull species (e.g. Great black-backed gull and Herring gull) have high vulnerability scores across both indices, whereas procellariform species (e.g. Manx shearwater and Northern fulmar) have higher vulnerability scores in the 40 m CVI compared to the 20 m CVI. Across both indices auks and divers have the lowest vulnerability scores. For the DVI, the family groups with the highest displacement vulnerability are auks and divers, whereas gulls and procellariform species have low displacement vulnerability.

Table 3.1. Seabird Collision Vulnerability Index (CVI) and Displacement Vulnerability Index (DVI) for species occurring in the Irish EEZ. Full details of input variables can be found in Eirwind D4.12.

	Turbine blade height					
	20 m		40 m			
Species	**CVI score**	**CVI rank**	**CVI score**	**CVI rank**	**DVI score**	**DVI rank**
Great black-backed gull	0.397	2	0.308	1	0.415	15
Manx shearwater	0.283	9	0.283	2	0.260	25
Northern fulmar	0.268	11	0.268	3	0.267	24
Herring gull	0.407	1	0.258	4	0.352	21
European storm-petrel	0.247	13	0.247	5	0.253	26
Lesser black-backed gull	0.355	4	0.214	6	0.332	22
Leach's storm-petrel	0.203	15	0.203	7	0.207	27
Roseate tern	0.331	6	0.202	8	0.605	8
European shag	0.367	3	0.199	9	0.670	6
Black-legged kittiwake	0.351	5	0.190	10	0.421	14
Great cormorant	0.178	16	0.178	11	0.407	17
Sandwich tern	0.283	8	0.173	12	0.454	13
Great skua	0.282	10	0.172	13	0.305	23
Arctic tern	0.156	17	0.156	14	0.409	16
Little tern	0.155	18	0.155	15	0.496	11
Common tern	0.254	12	0.155	16	0.407	17
Greater scaup	0.151	19	0.151	17	0.605	8
Great-crested grebe	0.146	20	0.146	18	0.477	12
Common gull	0.320	7	0.131	19	0.362	19
Northern gannet	0.226	14	0.131	20	0.586	10
Common guillemot	0.097	22	0.097	21	0.743	4
Black guillemot	0.089	23	0.089	22	0.645	7
Atlantic puffin	0.088	24	0.088	23	0.693	5
Razorbill	0.079	25	0.079	24	0.802	2
Black-headed gull	0.137	21	0.069	25	0.362	19
Great northern diver	0.000	26	0.000	26	0.902	1
Red-throated diver	0.000	26	0.000	26	0.751	3

3.2 Vulnerability maps

Vulnerability maps for summer (Figure 3.1) and winter (Figure 3.2) show how the spatial distribution of vulnerability (CVI and DVI) in the Irish EEZ changes with season. Grid squares are ranked as areas of 'Highest vulnerability' for vulnerability values in the 80th percentile, 'High vulnerability' for values in the 60th percentile and 'Low vulnerability' for values below the 60th percentile following recommendations from the original windfarm vulnerability index (Garthe and Huppop, 2004) and discussions with the EirWind consortium partners. Percentile values for the CVI 20 m maps were also used for the CVI 40 m maps to allow for comparison between the two.

Across seasons and all vulnerability maps, the Irish Sea is designated 'highest vulnerability'. In the summer months, vulnerability is more concentrated closer to the shore with additional patches of vulnerability along the edge of the continental shelf, both at the porcupine bank and north towards Scotland. In winter, vulnerability is more diffuse with much larger areas of high and highest vulnerability. In both summer and winter there is a clear reduction in collision vulnerability between the 20 m CVI and 40 m CVI.

Summer

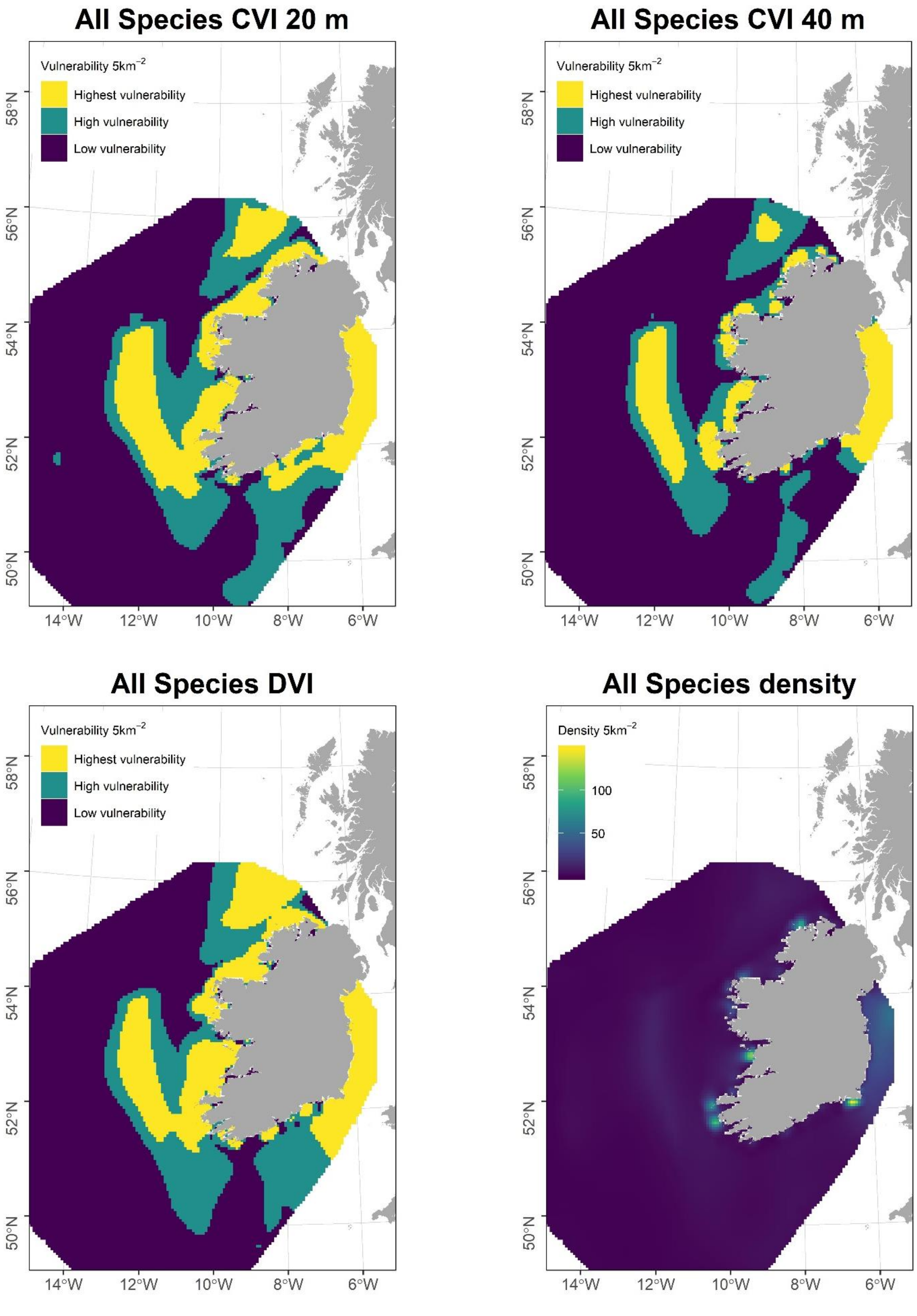

Figure 3.1 Distribution maps of the Irish EEZ in summer showing a) seabird vulnerability to collision risk for turbine sweep zones starting 20 m above sea level; b) seabird vulnerability to collision risk for turbine sweep zones starting 40 m above sea level; c) seabird vulnerability to displacement due to vessels/structure; and d) seabird density. Grid squares are ranked as areas of 'Highest vulnerability' for values in the 80th percentile, 'High vulnerability' for values in the 60th percentile and 'Low vulnerability' for values below the 60th percentile.

Winter

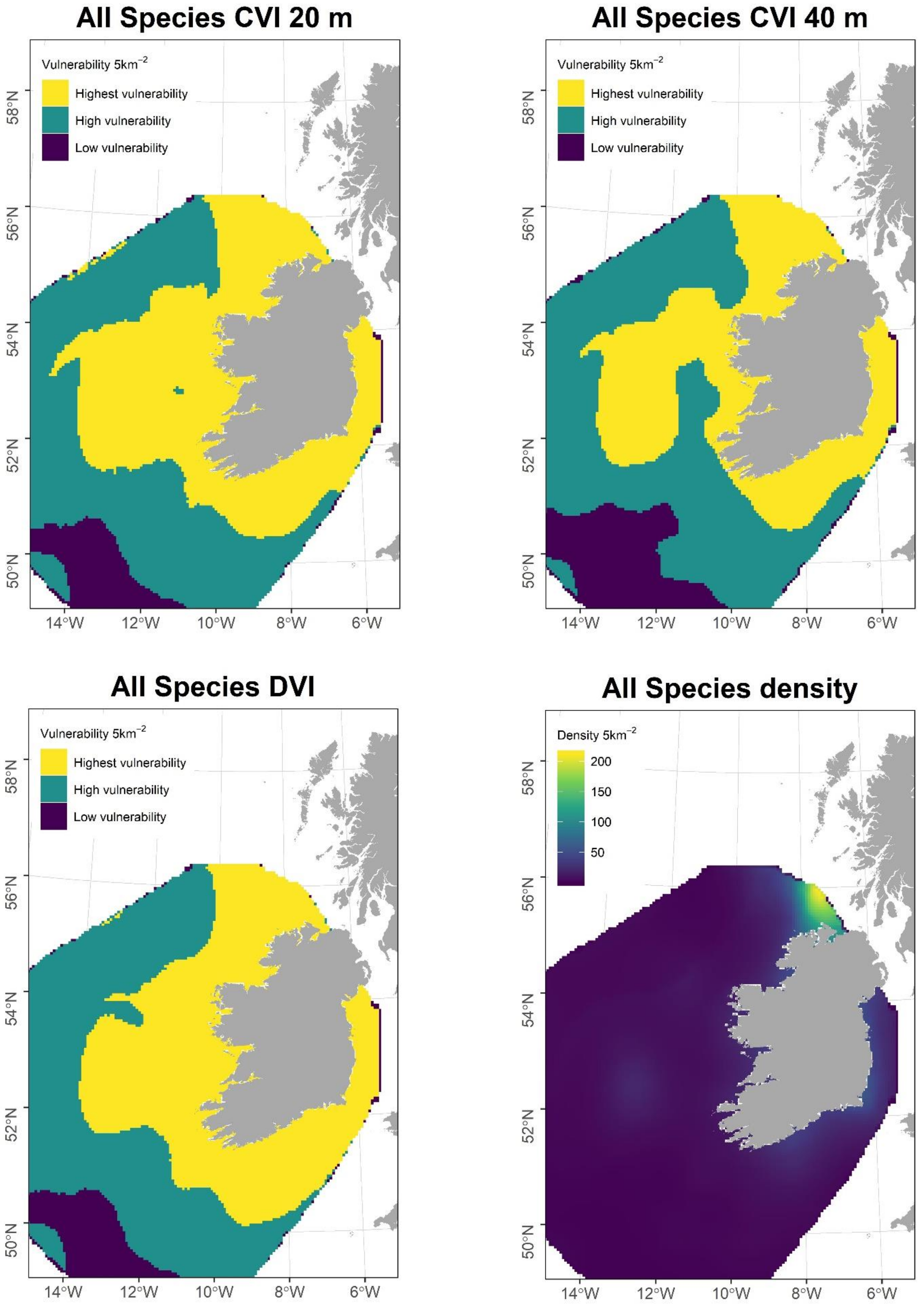

Figure 3.2 Distribution maps of the Irish EEZ in winter showing a) seabird vulnerability to collision risk for turbine sweep zones starting 20 m above sea level; b) seabird vulnerability to collision risk for turbine sweep zones starting 40 m above sea level; c) seabird vulnerability to displacement due to vessels/structures; and d) seabird density. Grid squares are ranked as areas of 'Highest vulnerability' for vulnerability values in the 80th percentile, 'High vulnerability' for values in the 60th percentile and 'Low vulnerability' for values below the 60th percentile.

4 Discussion

The analysis shows the areas of highest seabird vulnerability to windfarms, whether due to collision or displacement/avoidance of infrastructure in Irish waters on a broad scale. In particular they highlight the importance of the Irish Sea across both seasons and regardless of vulnerability type (CVI or DVI). However, it should be noted that the vulnerability maps show relative vulnerability of an area compared to the rest of the region covered by the map (e.g. the entire Irish EEZ), and that relative vulnerability will change according to the region covered by the analysis. The outputs of this report determine spatial vulnerability at a national scale to help broad-scale siting decisions, and finer-scale vulnerability maps should be generated within smaller areas of interest to help inform siting decisions and additional survey/data needs to mitigate potential impacts. For example, the Irish Sea vulnerability maps contained in D4.12 provide finer details on relative vulnerability within the Irish Sea at a resolution of 4 km^2.

For both seasons there is a reduction in the area of highest vulnerability in the CVI 40 m map compared to the CVI 20 m map, reinforcing the need to account for the size of turbine that will be deployed when assessing seabird vulnerability at a site.

The relative importance of coastal areas in the summer compared to offshore areas, especially on the south west coast, can be seen across indices. This reflects the concentration of birds in waters surrounding colonies during the breeding season. The south west coast of Ireland hosts internationally important breeding colonies of a number of species, e.g. European storm-petrel and Manx shearwater, which Ireland is required to protect under the EU Birds Directive (2009/147/EC) and Habitats Directive (92/43/EEC). In contrast, birds are not tied to the colony during the winter season and are distributed more widely across the Irish EEZ or migrate out of the region, thus the areas of highest vulnerability spread further offshore in winter.

4.1 Data limitations & future work

Whilst the distribution data used for this study represents the best available data for seabird distributions in Irish waters there are still gaps in coverage, particularly on the south and west coasts where projected distributions were required to fill data gaps. Additional surveys to cover these gaps would help to reduce uncertainty around vulnerability on these coasts. As surveys need to be conducted over large spatial scales to determine relative vulnerability along the entire coast, mechanisms for funding this through government funding or large consortia should be explored.

Spatial vulnerability maps are not intended as a replacement for Environmental Impact Assessment (EIA) or Appropriate Assessment (AA) of sites, but to help inform broader site selection with respect to minimising potential impacts on seabirds. Further survey work at a finer resolution, or tracking studies to determine the fine-scale habitat use of vulnerable species will need to be carried out upon site selection. This is particularly true if there is a significant time gap between site selection and the data underlying vulnerability maps in this report. Distribution data collected for site selection and EIA/AA purposes could subsequently be used to produce vulnerability maps within selected areas to inform the best configuration of turbines to minimise impacts by following the detailed methodology outlined in Eirwind D4.12 'Initial results for the assessment of seabird vulnerability to offshore windfarms in Ireland' summarised in Section 2.3.

The vulnerability maps produced for this report can only account for potential vulnerability rather than actual risk, which requires site scenario development and collision risk modelling (e.g. see Band 2012). In many cases the development of offshore windfarm sites in Ireland is not yet at the stage where collision risk modelling can be applied. However, given the early stage of development there is an opportunity for cumulative impact assessments to be undertaken at a strategic national level (see Masden et al. 2010 for a conceptual framework).

5 Conclusions

The outputs of this study provide an important resource for windfarm site selection in Irish waters. The vulnerability maps indicate the location of areas of relatively higher vulnerability on a broad national scale, highlighting where further surveys, monitoring, tracking studies, or mitigation might be needed. **Vulnerability maps are not intended to define areas that should or should not be developed for wind energy**. Additional seabird surveys at a national level will help to reduce uncertainty in areas with limited data (e.g. the south and west coasts), and at a site level will provide fine-scale information about areas of highest vulnerability. Vulnerability Indices also illustrate how species and risk factors will vary by site and season. Combined use of vulnerability indices and site specific species distribution maps will provide a powerful tool for defining the species and areas most at risk in a planned development site. Appropriate monitoring and mitigation measures can then be put in place prior to development, with the aim of reducing the environmental impacts from offshore windfarm development.

6 References

Band, B. (2012). Using a collision risk model to assess bird collision risks for offshore windfarms. British Trust for Ornithology.

Cañadas A, Hammond P (2008) Abundance and habitat preferences of the short-beaked common dolphin *Delphinus delphis* in the southwestern Mediterranean: implications for conservation. *Endangered Species Research* 4:309-331

Certain, G., Jørgensen, L. L., Christel, I., Planque, B., & Bretagnolle, V. (2015) Mapping the vulnerability of animal community to pressure in marine systems: disentangling pressure types and integrating their impact from the individual to the community level. *ICES Journal of Marine Science*, 72(5), pp. 1470–1482.

Critchley, E.J., Cummins, V. and Jessopp, M.J. (2019). Initial report on methodology for the assessment of seabird vulnerability to offshore wind farms in Ireland, EirWind Project Deliverable D4.11 Report, MaREI Centre for Marine and Renewable Energy, Cork, Ireland.

Critchley, E.J., Cummins, V. and Jessopp, M.J. (2019). Initial results for the assessment of seabird vulnerability to offshore wind farms in Ireland, Deliverable D4.12 Report, MaREI Centre for Marine and Renewable Energy, Cork, Ireland.

Critchley, E.J., Grecian, W.J., Kane, A., Jessopp, M.J., Quinn, J.L., (2018) Marine protected areas show low overlap with projected distributions of seabird populations in Britain and Ireland. *Biological Conservation,* 224, 309–317. doi:10.1016/j.biocon.2018.06.007

Critchley, E. J., Grecian, W. J., Benninson, A., Kane, A., Wischnewski, S., Cañadas, A., Tierney, D., Quinn, J. L. and Jessopp, M. J. (2019) Assessing the effectiveness of foraging radius models for seabird distributions using biotelemetry and survey data. *Ecography* doi: 10.1111/ecog.04653

Jessopp, M., Mackey, M., Luck, C., Critchley, E., Bennison, A, and Rogan, E. (2018) *The seasonal distribution and abundance of seabirds in the western Irish Sea 2016*.

Masden, E.A., Fox, A.D., Furness, R.W., Bullman, R. and Haydon, D.T., (2010) Cumulative impact assessments and bird/wind farm interactions: Developing a conceptual framework. *Environmental Impact Assessment Review*, 30(1), pp.1-7.

Rogan, E., Breen, P., Mackey, M., Cañadas, A., Scheidat, M., Geelhoed, S. & Jessopp, M. (2018) *Aerial Surveys of Cetaceans and Seabirds in Irish waters : Occurrence , distribution and abundance in 2015-2017*.

Wade, H.M., Masden, E.A., Jackson, A.C., Furness, R.W. (2016) 'Incorporating data uncertainty when estimating potential vulnerability of Scottish seabirds to marine renewable energy developments', *Marine Policy*. Elsevier, 70, pp. 108–113.